# Supporting Information for:

# A Room-Temperature Alternative to the Arbuzov Reaction: the Reductive Deoxygenation of Acyl Phosphonates

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**Chemistry—General**.

All reactions were performed under argon using solvents that were dried and purified according to the method of Pangborn et al.[i] All flasks and vials were oven dried at 122°C and cooled in a desiccator box containing anhydrous calcium sulfate. But for the exceptions listed here, commercial reagents were purified according to the methods compiled by Armengo and Perrin.[ii] Potassium t-butoxide, anhydrous t-butanol, and 1.0 M hydrazine in THF solution were used as purchased from Aldrich without further purification and stored under argon. Hydrocinamic acids that could not be purchased were synthesized from the corresponding benzaldehyde according to a literature procedure.[iii] Reactions were monitored by thin-layer chromatography on Merck Siligel 60-$F_{254}$. Compounds were visualized with a UV lamp (254 nm) and stained with potassium permanganate solution. Column chromatography was carried out in accordance with the methods of Still et al.[iv] using EMD-Merck silica gel 60, 230-400 mesh ASTM. $^{1}H$, $^{31}P$ and $^{13}C$ NMR spectra were acquired on a Varian Mercury 300 MHz spectrometer. High-resolution mass spectrometry was performed on a JEOL JMS-600H HRMS using an Electrospray Ion Source.

**Chemistry—Synthesis.**

**Diethyl ethylphosphonate (Table 1, entry 1).** Acetyl chloride (72µL, 1 mmol) was added to dichloromethane (8 mL) in a 25 mL roundbottomed flask and cooled on an icebath. Triethylphosphite (171 µL, 1 mmol) was then added dropwise to this chilled solution under stirring, then the reaction was allowed to come to room temperature. After two hours stirring, the reaction was reduced *in vacuo*, and benzoic acid (245 mg, 2 mmol) was added directly to the residue, followed by benzene (10 mL). The mixture was stirred to dissolve completely, then hydrazine solution (1.05 mL, 1.0 M in THF, 1.05 mmol) was added dropwise under rapid stirring. After 90 minutes, the reaction was flash-frozen and lyophilized. After lyophilization, 1:1 v/v tetrahydrofuran:*tert*-butanol (10 mL) was added to the flask and stirred to dissolve the solid. Potassium *tert*-butoxide solution (5 mL, 0.6 M in 1:1 v/v tetrahydrofuran:*tert*-butanol, 3 mmol) was then added to the stirring solution in one portion. After 6 h room temperature stirring, the reaction was diluted with ethyl acetate (50 mL), quenched with 1 N HCl (20 mL), washed with saturated sodium bicarbonate (2 x 15 mL), then with brine (15 mL), dried on sodium sulfate, reduced *in vacuo*, then purified by flash chromatography on silica (15% acetone in dichloromethane) to give the desired product as a colorless liquid; 97.0 mg (58.4%). $^{1}H$ NMR (300 MHz, $CDCl_3$) δ 3.98-4.12 (m, 4H), 1.62-1.68, (dq, 2H, $J$ = 18.2, 7.8 Hz), 1.28 (t, 3H, $J$ = 7.1 Hz), 1.11 (dt, 6H, $J$ = 20.0, 7.8 Hz); $^{13}C$ NMR (75 MHz, $CDCl_3$) δ 61.4, 61.3, 19.7, 17.8, 16.4, 16.5, 6.5, 6.4; $^{31}P$ NMR (121 MHz, $CDCl_3$) δ 33.6; HRMS ($FAB^+$) calculated for $[C_6H_{16}O_3P]$ ($[M+H]^+$) 167.0837, found 167.0836.[v]

**Diethyl propylphosphonate. (Table 1, entry 2).** Propionyl chloride (87µL, 1 mmol) was added to dichloromethane (8 mL) in a 25 mL roundbottomed flask and cooled on an icebath. Triethylphosphite (171 µL, 1 mmol) was then added dropwise to this chilled solution under stirring, then the reaction was allowed to come to room temperature. After one hour stirring, the reaction was reduced *in vacuo*, and benzoic acid (245 mg, 2 mmol) was added directly to the residue, followed by benzene (10 mL). The mixture was stirred to dissolve completely, then

hydrazine solution (1.05 mL, 1.0 M in THF, 1.05 mmol) was added dropwise under rapid stirring. After 60 minutes, the reaction was flash-frozen and lyophilized. After lyophilization, 1:1 v/v tetrahydrofuran:*tert*-butanol (10 mL) was added to the flask and stirred to dissolve the solid. Potassium *tert*-butoxide solution (5 mL, 0.6 M in 1:1 v/v tetrahydrofuran:*tert*-butanol, 3 mmol) was then added to the stirring solution in one portion. After 6 h room temperature stirring, the reaction was diluted with ethyl acetate (50 mL), quenched with 1 N HCl (20 mL), washed with saturated sodium bicarbonate (2 x 15 mL), then with brine (15 mL), dried on sodium sulfate, reduced *in vacuo*, then purified by flash chromatography on silica (10% acetone in dichloromethane) to give the desired product as a colorless liquid; 133.8 mg (74.3 %). $^{1}$H NMR (300 MHz, $CDCl_3$) δ 3.93-4.11 (m, 4H), 1.48-1.70, (m, 4H), 1.25 (t, 6H, $J$ = 7.1 Hz), 0.92-0.97 (m, 3H); $^{13}$C NMR (75 MHz, $CDCl_3$) δ 61.3, 61.2, 28.6, 26.7, 16.4, 16.3, 16.1, 16.0, 15.3, 15.1; $^{31}$P NMR (121 MHz, $CDCl_3$) δ 32.2; HRMS ($FAB^+$) calculated for [$C_7H_{18}O_3P$] ([M+H]$^+$) 181.0994, found 181.1003.[vi]

**Diethyl *sec*-butylphosphonate. (Table 1, entry 3b).** 2-Methylpropionyl chloride (106 mg, 1 mmol) was added to dichloromethane (8 mL) in a 25 mL roundbottomed flask and cooled on an icebath. Triethylphosphite (171 µL, 1 mmol) was then added dropwise to this chilled solution under stirring, then the reaction was allowed to come to room temperature. After one hour stirring, the reaction was reduced *in vacuo*, and benzoic acid (500 mg, 4 mmol) was added directly to the residue, followed by benzene (10 mL). The mixture was stirred to dissolve completely, then hydrazine solution (1.05 mL, 1.0 M in THF, 1.05 mmol) was added dropwise under rapid stirring. After 60 minutes, the reaction was flash-frozen and lyophilized. After lyophilization, 1:1 v/v tetrahydrofuran:*tert*-butanol (7 mL) was added to the flask and stirred to dissolve the solid. Potassium *tert*-butoxide solution (8 mL, 0.6 M in 1:1 v/v tetrahydrofuran:*tert*-butanol, 5 mmol) was then added to the stirring solution in one portion. After 12 h room temperature stirring, the reaction was diluted with ethyl acetate (50 mL), quenched with 1 N HCl (20 mL), washed with saturated sodium bicarbonate (2 x 15 mL), then with brine (15 mL), dried on sodium sulfate, reduced *in vacuo*, then purified by flash chromatography on silica (12% acetone in dichloromethane) to give the desired product as a colorless liquid; 88.5 mg (45.6 %). $^{1}$H NMR (300 MHz, $CDCl_3$) δ 3.96-4.14 (m, 4H), 1.95-2.12 (m, 1H), 1.63 (dd, 2H, $J$ = 18.2, 6.8 Hz), 1.28 (t, 6H, $J$ = 7.1 Hz), 1.01 (dd, 6H $J$ = 6.7, 1.0 Hz); $^{13}$C NMR (75 MHz, $CDCl_3$) δ 61.2, 61.1, 35.4, 33.6, 24.1, 24.0, 23.7, 23.7, 16.5, 16.4; $^{31}$P NMR (121 MHz, $CDCl_3$) δ 31.6; HRMS ($FAB^+$) calculated for [$C_8H_{20}O_3P$] ([M+H]$^+$) 195.1150, found 195.1173.[vii]

**Diethyl benzylphosphonate. (Table 1, entry 5b).** Benzoyl chloride (117 µL, 1 mmol) was added to dichloromethane (8 mL) in a 25 mL roundbottomed flask and cooled on an icebath. Triethylphosphite (171 µL, 1 mmol) was then added dropwise to this chilled solution under stirring, then the reaction was allowed to come to room temperature. After one hour stirring, the reaction was reduced *in vacuo*, and *ortho*-bromobenzoic acid (400 mg, 2 mmol) was added directly to the residue, followed by benzene (10 mL). The mixture was stirred, then hydrazine solution (1.05 mL, 1.0 M in THF, 1.05 mmol) was added dropwise under rapid stirring. After 6 hours, the reaction was flash-frozen and lyophilized. After lyophilization, 1:1 v/v tetrahydrofuran:*tert*-butanol (10 mL) was added to the flask and stirred to dissolve the solid. Potassium *tert*-butoxide solution (5 mL, 0.6 M in 1:1 v/v tetrahydrofuran:*tert*-butanol, 3 mmol) was then added to the stirring solution in one portion. After 4 h room temperature stirring, the reaction was diluted with ethyl acetate (50 mL), quenched with 1 N HCl (20 mL), washed with

saturated sodium bicarbonate (2 x 15 mL), then with brine (15 mL), dried on sodium sulfate, reduced *in vacuo*, then purified by flash chromatography on silica (15% acetone in dichloromethane) to give the desired product as a colorless liquid; 68.6 mg (30.1 %). $^{1}$H NMR (300 MHz, $CDCl_3$) δ 7.23-7.31 (m, 5H), 3.95-4.06 (m, 4H), 3.15 (d, 2H, *J* = 21.6 Hz), 1.24 (t, 6H, *J* = 7.1 Hz); $^{13}$C NMR (75 MHz, $CDCl_3$) δ 131.6, 131.6, 129.8, 129.7, 128.5, 128.5, 126.9, 126.8, 62.1, 62.1, 34.3, 33.2, 16.4, 16.3; $^{31}$P NMR (121 MHz, $CDCl_3$) δ 26.4; HRMS ($FAB^+$) calculated for $[C_{11}H_{18}O_3P]$ ($[M+H]^+$) 229.0994, found 229.1005.[viii]

**Diethyl 2-phenylethylphosphonate. (Table 1, entry 6).** Phenylacetyl chloride (154 mg, 1 mmol) was added to dichloromethane (8 mL) in a 25 mL roundbottomed flask and cooled on an icebath. Triethylphosphite (171 µL, 1 mmol) was then added dropwise to this chilled solution under stirring, then the reaction was allowed to come to room temperature. After two hours stirring, the reaction was reduced *in vacuo*, and benzoic acid (245 mg, 2 mmol) was added directly to the residue, followed by benzene (10 mL). The mixture was stirred to dissolve completely, then hydrazine solution (1.05 mL, 1.0 M in THF, 1.05 mmol) was added dropwise under rapid stirring. After 60 minutes, the reaction was flash-frozen and lyophilized. After lyophilization, 1:1 v/v tetrahydrofuran:*tert*-butanol (10 mL) was added to the flask and stirred to dissolve the solid. Potassium *tert*-butoxide solution (5 mL, 0.6 M in 1:1 v/v tetrahydrofuran:*tert*-butanol, 3 mmol) was then added to the stirring solution in one portion. After 6 h room temperature stirring, the reaction was diluted with ethyl acetate (50 mL), quenched with 1 N HCl (20 mL), washed with saturated sodium bicarbonate (2 x 15 mL), then with brine (15 mL), dried on sodium sulfate, reduced *in vacuo*, then purified by flash chromatography on silica (15% acetone in dichloromethane) to give the desired product as a yellow liquid; 158.1 mg (65.3 %). $^{1}$H NMR (300 MHz, $CDCl_3$) δ 7.16-7.30 (m, 5H), 4.03-4.13 (m, 4H), 2.85-2.94 (m, 2H), 1.98-2.10 (m, 2H), 1.30 (t, 6H *J* = 7.0 Hz); $^{13}$C NMR (75 MHz, $CDCl_3$) δ 141.1, 140.8, 128.5, 128.0, 126.3, 61.6, 61.5, 28.6, 28.5, 28.5, 26.6, 16.5, 16.4; $^{31}$P NMR (121 MHz, $CDCl_3$) δ 30.8; HRMS ($FAB^+$) calculated for $[C_{12}H_{20}O_3P]$ ($[M+H]^+$) 243.1150, found 243.1158.[8]

**Diethyl 3-phenylpropyl-1-phosphonate. (Table 1, entry 7).** 3-Phenylpropionyl chloride (149 µL, 1 mmol) was added to dichloromethane (8 mL) in a 25 mL roundbottomed flask and cooled on an icebath. Triethylphosphite (171 µL, 1 mmol) was then added dropwise to this chilled solution under stirring, then the reaction was allowed to come to room temperature. After two hours stirring, the reaction was reduced *in vacuo*, and benzoic acid (245 mg, 2 mmol) was added directly to the residue, followed by benzene (10 mL). The mixture was stirred to dissolve completely, then hydrazine solution (1.05 mL, 1.0 M in THF, 1.05 mmol) was added dropwise under rapid stirring. After 90 minutes, the reaction was flash-frozen and lyophilized. After lyophilization, 1:1 v/v tetrahydrofuran:*tert*-butanol (10 mL) was added to the flask and stirred to dissolve the solid. Potassium *tert*-butoxide solution (5 mL, 0.6 M in 1:1 v/v tetrahydrofuran:*tert*-butanol, 3 mmol) was then added to the stirring solution in one portion. After 6 h room temperature stirring, the reaction was diluted with ethyl acetate (50 mL), quenched with 1 N HCl (20 mL), washed with saturated sodium bicarbonate (2 x 15 mL), then with brine (15 mL), dried on sodium sulfate, reduced *in vacuo*, then purified by flash chromatography on silica (100% ethyl acetate) to give the desired product as a faintly yellow liquid; 189.0 mg (73.8 %). $^{1}$H NMR (300 MHz, $CDCl_3$) δ 7.12-7.28 (m, 5H), 3.95-4.12 (m, 4H), 2.64-2.69 (t, 2H, *J* = 7.4 Hz), 1.84-1.97 (m, 2H), 1.64-1.75 (m, 2H), 1.27 (t, 6H *J* = 7.1 Hz); $^{13}$C NMR (75 MHz, $CDCl_3$) δ 141.0, 141.0, 128.4, 128.3, 126.0, 61.4, 61.3, 36.5, 36.3, 26.0, 24.2, 24.1, 24.1, 16.5, 16.4; $^{31}$P NMR

(121 MHz, $CDCl_3$) δ 32.0; HRMS ($FAB^+$) calculated for [$C_{13}H_{22}O_3P$] ([M+H]$^+$) 257.1307, found 257.1302.[8]

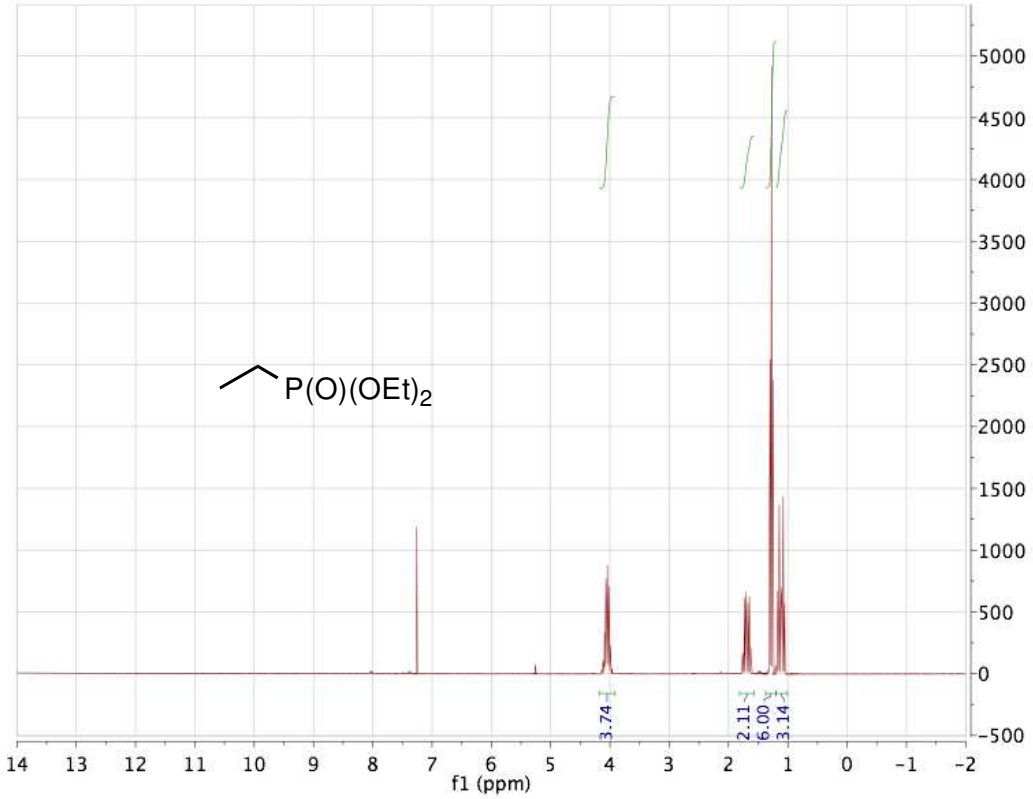
**Diethyl 3-phenylpropyl-1-phosphonate. (Table 1, entry 8).** 3-Phenylpropionic acid (150 mg, 1 mmol) was dissolved in dichloromethane (10 mL) in a 25 mL roundbottomed flask and cooled on an icebath. Oxalyl chloride (100 µL, 1.2 mmol) was added in one portion under stirring, and the reaction was allowed to come to room temperature. After 12 hours the reaction was reduced *in vacuo*, then the residue was redissolved in dichloromethane (8 mL) and cooled on an icebath. Triethylphosphite (171 µL, 1 mmol) was then added dropwise to this chilled solution under stirring, then the reaction was allowed to come to room temperature. After two hours stirring, the reaction was reduced *in vacuo*, and benzoic acid (245 mg, 2 mmol) was added directly to the residue, followed by benzene (10 mL). The mixture was stirred to dissolve completely, then hydrazine solution (1.05 mL, 1.0 M in THF, 1.05 mmol) was added dropwise under rapid stirring. After 90 minutes, the reaction was flash-frozen and lyophilized. After lyophilization, 1:1 v/v tetrahydrofuran:*tert*-butanol (10 mL) was added to the flask and stirred to dissolve the solid. Potassium *tert*-butoxide solution (5 mL, 0.6 M in 1:1 v/v tetrahydrofuran:*tert*-butanol, 3 mmol) was then added to the stirring solution in one portion. After 6 h room temperature stirring, the reaction was diluted with ethyl acetate (50 mL), quenched with 1 N HCl (20 mL), washed with saturated sodium bicarbonate (2 x 15 mL), then with brine (15 mL), dried on sodium sulfate, reduced *in vacuo*, then purified by flash chromatography on silica (100% ethyl acetate) to give the desired product as a faintly yellow liquid; 177.0 mg (69.1 %). $^1$H NMR (300 MHz, $CDCl_3$) δ 7.15-7.30 (m, 5H), 3.97-4.15 (m, 4H), 2.66-2.71 (t, 2H, $J$ = 7.4 Hz), 1.84-1.99 (m, 2H), 1.66-1.78 (m, 2H), 1.29 (t, 6H $J$ = 7.1 Hz); $^{13}$C NMR (75 MHz, $CDCl_3$) δ 141.0, 141.0, 128.5, 128.4, 126.0, 61.4, 61.3, 36.5, 36.3, 26.0, 24.2, 24.1, 16.5, 16.4; $^{31}$P NMR (121 MHz, $CDCl_3$) δ 32.0; HRMS ($FAB^+$) calculated for [$C_{13}H_{22}O_3P$] ([M+H]$^+$) 257.1307, found 257.1302.

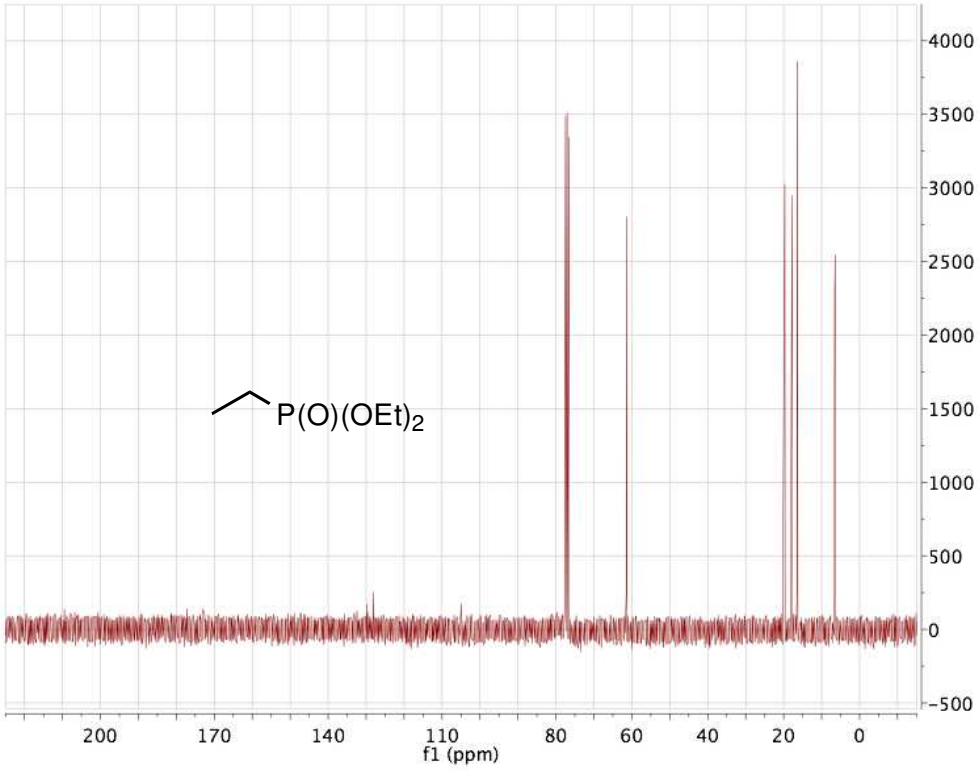
**Diethyl 3-(4-methoxyphenyl)propyl-1-phosphonate. (Table 1, entry 9).** 3-(4-methoxyphenyl) propionic acid (180 mg, 1 mmol) was dissolved in dichloromethane (10 mL) in a 25 mL roundbottomed flask and cooled on an icebath. Oxalyl chloride (100 µL, 1.2 mmol) was added in one portion under stirring, and the reaction was allowed to come to room temperature. After 12 hours the reaction was reduced *in vacuo*, then the residue was redissolved in dichloromethane (8 mL) and cooled on an icebath. Triethylphosphite (171 µL, 1 mmol) was then added dropwise to this chilled solution under stirring, then the reaction was allowed to come to room temperature. After two hours stirring, the reaction was reduced *in vacuo*, and benzoic acid (245 mg, 2 mmol) was added directly to the residue, followed by benzene (10 mL). The mixture was stirred to dissolve completely, then hydrazine solution (1.05 mL, 1.0 M in THF, 1.05 mmol) was added dropwise under rapid stirring. After 90 minutes, the reaction was flash-frozen and lyophilized. After lyophilization, 1:1 v/v tetrahydrofuran:*tert*-butanol (10 mL) was added to the flask and stirred to dissolve the solid. Potassium *tert*-butoxide solution (5 mL, 0.6 M in 1:1 v/v tetrahydrofuran:*tert*-butanol, 3 mmol) was then added to the stirring solution in one portion. After 6 h room temperature stirring, the reaction was diluted with ethyl acetate (50 mL), quenched with 1 N HCl (20 mL), washed with saturated sodium bicarbonate (2 x 15 mL), then with brine (15 mL), dried on sodium sulfate, reduced *in vacuo*, then purified by flash chromatography on silica (100% ethyl acetate) to give the desired product as a faintly yellow liquid; 187.4 mg (65.5 %). $^1$H NMR (300 MHz, $CDCl_3$) δ 7.03-7.06 (m, 2H), 6.77-6.80 (m 2H), 3.94-4.12 (m, 4H), 3.74 (s, 3H), 2.60 (t, 2H, $J$ = 7.4 Hz), 1.79-1.93 (m, 2H), 1.62-1.75 (m, 2H),

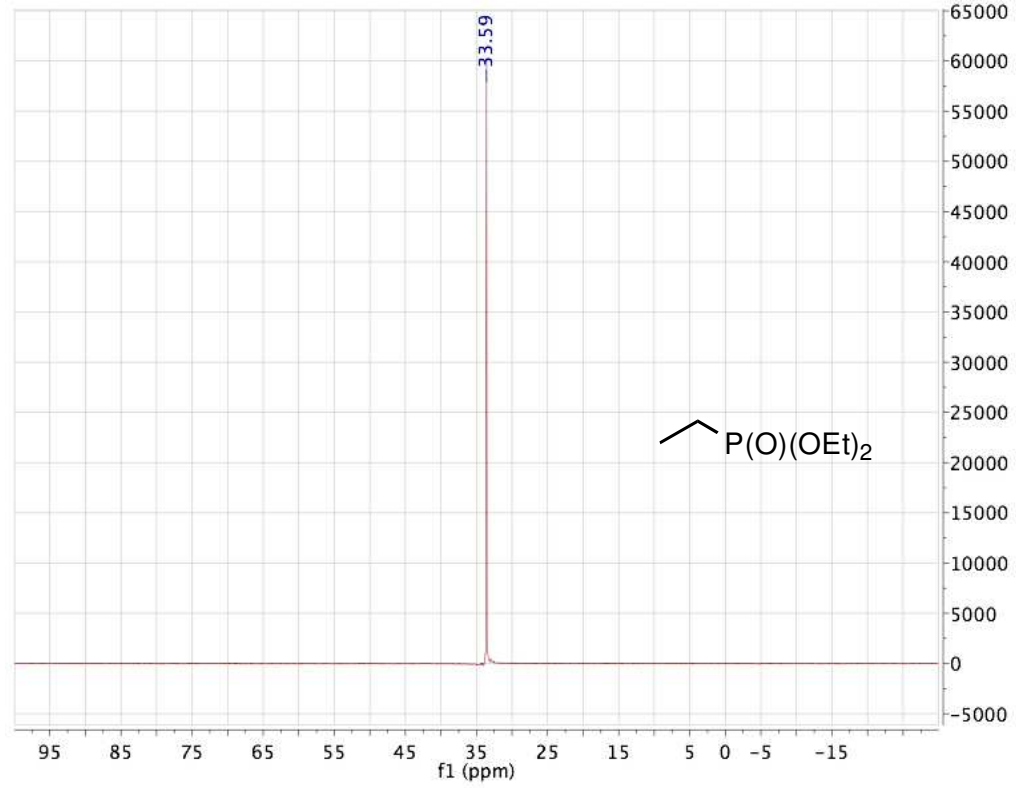
1.27 (t, 6H $J$ = 7.1 Hz); $^{13}$C NMR (75 MHz, $CDCl_3$) δ 157.9, 133.1, 133.0, 129.3, 113.8, 61.4, 61.3, 55.2, 35.6, 35.4, 25.9, 24.3, 24.3, 24.0, 16.5, 16.4; $^{31}$P NMR (121 MHz, $CDCl_3$) δ 32.2; HRMS ($FAB^+$) calculated for $[C_{14}H_{23}O_4P]$ ($[M+H]^+$) 286.1334, found 286.1342.

**Diethyl 3-(4-cyanophenyl)propyl-1-phosphonate. (Table 1, entry 10).** 3-(4-cyanophenyl) propionic acid (175 mg, 1 mmol) was dissolved in dichloromethane (10 mL) in a 25 mL roundbottomed flask and cooled on an icebath. A drop of dimethylformamide was added. Oxalyl chloride (100 µL, 1.2 mmol) was added in one portion under stirring, and the reaction was allowed to come to room temperature. After 12 hours the reaction was reduced *in vacuo*, then the residue was redissolved in dichloromethane (8 mL) and cooled on an icebath. Triethylphosphite (171 µL, 1 mmol) was then added dropwise to this chilled solution under stirring, then the reaction was allowed to come to room temperature. After two hours stirring, the reaction was reduced *in vacuo*, and benzoic acid (245 mg, 2 mmol) was added directly to the residue, followed by benzene (10 mL). The mixture was stirred to dissolve completely, then hydrazine solution (1.05 mL, 1.0 M in THF, 1.05 mmol) was added dropwise under rapid stirring. After 90 minutes, the reaction was flash-frozen and lyophilized. After lyophilization, 1:1 v/v tetrahydrofuran:*tert*-butanol (10 mL) was added to the flask and stirred. Potassium *tert*-butoxide solution (5 mL, 0.6 M in 1:1 v/v tetrahydrofuran:*tert*-butanol, 3 mmol) was then added to the stirring mixture in one portion. After 6 h room temperature stirring, the reaction was diluted with ethyl acetate (50 mL), quenched with 1 N HCl (20 mL), washed with saturated sodium bicarbonate (2 x 15 mL), then with brine (15 mL), dried on sodium sulfate, reduced *in vacuo*, then purified by flash chromatography on silica (20% acetone in dichloromethane) to give the desired product as a colorless liquid; 163.5 mg (58.2 %). $^1$H NMR (300 MHz, $CDCl_3$) δ 7.51-7.55 (m, 2H), 7.23-7.27 (m 2H), 3.96-4.13 (m, 4H), 2.73 (t, 2H, $J$ = 7.5 Hz), 1.83-1.97 (m, 2H), 1.63-1.74 (m, 2H), 1.27 (t, 6H $J$ = 7.1 Hz); $^{13}$C NMR (75 MHz, $CDCl_3$) δ 146.7, 132.2, 129.3, 118.9, 110.0, 61.6, 61.5, 36.5, 36.3, 25.9, 24.0, 23.8, 23.7, 16.5, 16.4; $^{31}$P NMR (121 MHz, $CDCl_3$) δ 31.3; HRMS ($FAB^+$) calculated for $[C_{14}H_{21}O_3NP]$ ($[M+H]^+$) 282.1259, found 282.1262.

**NMR Data**

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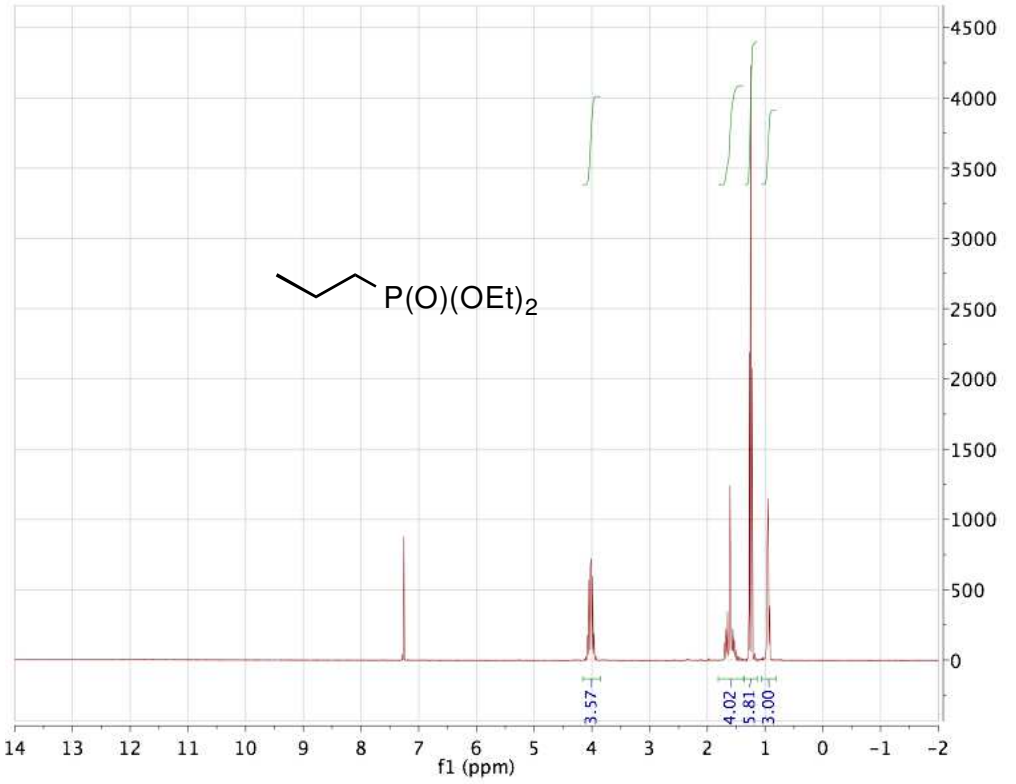
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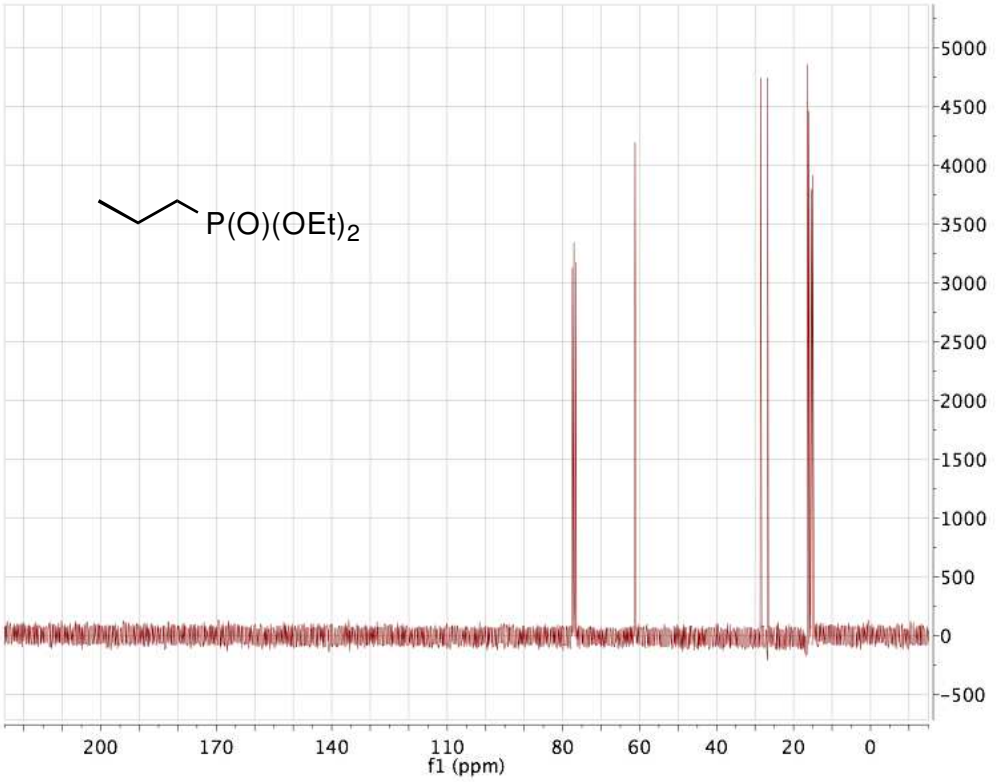
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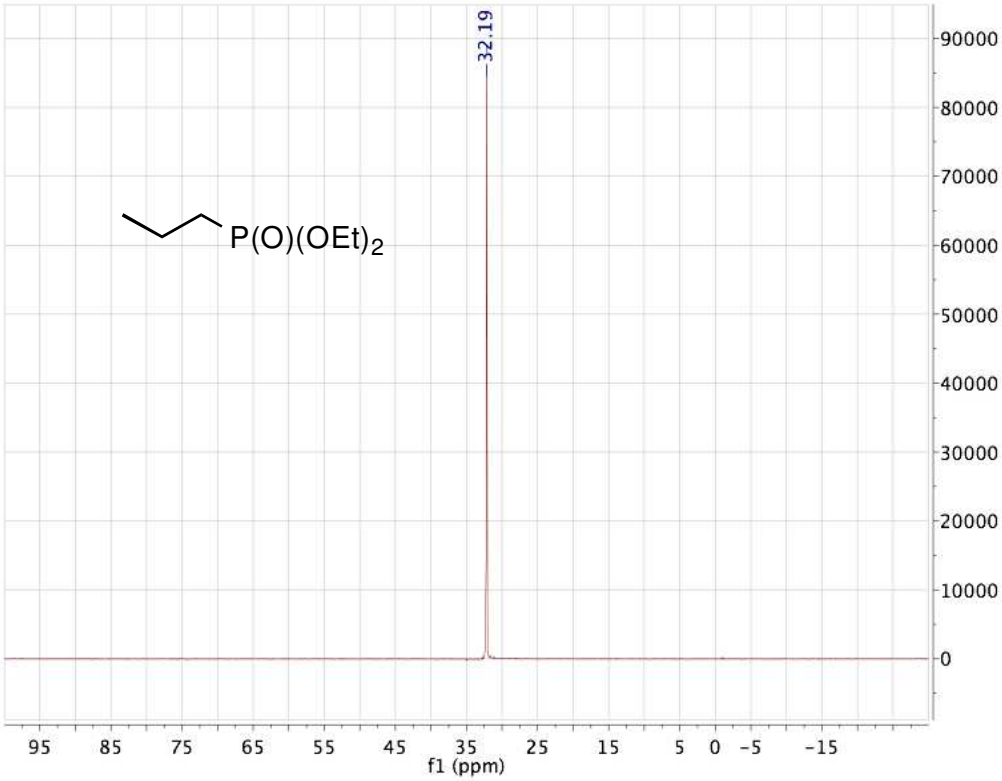
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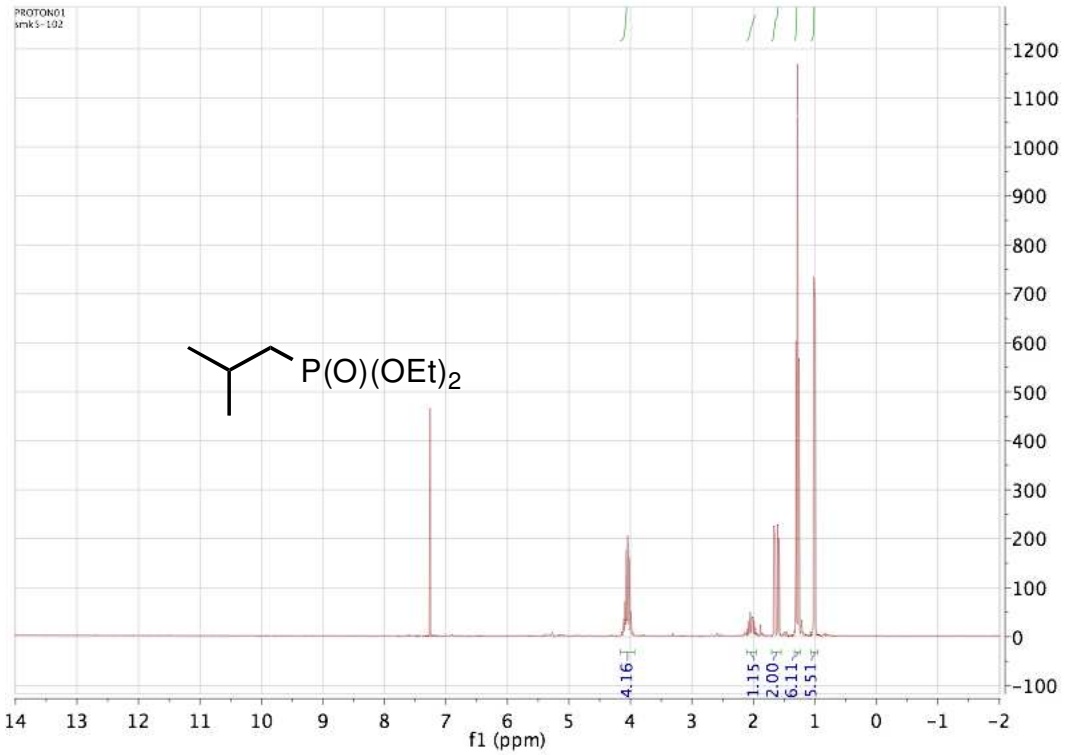
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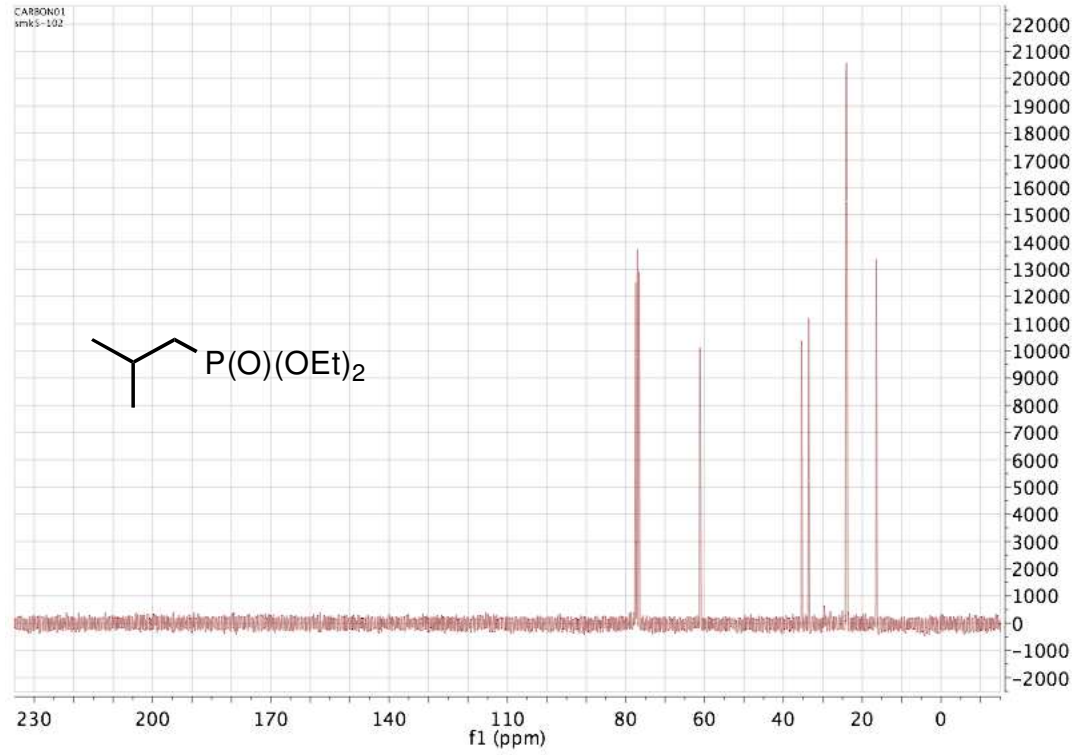
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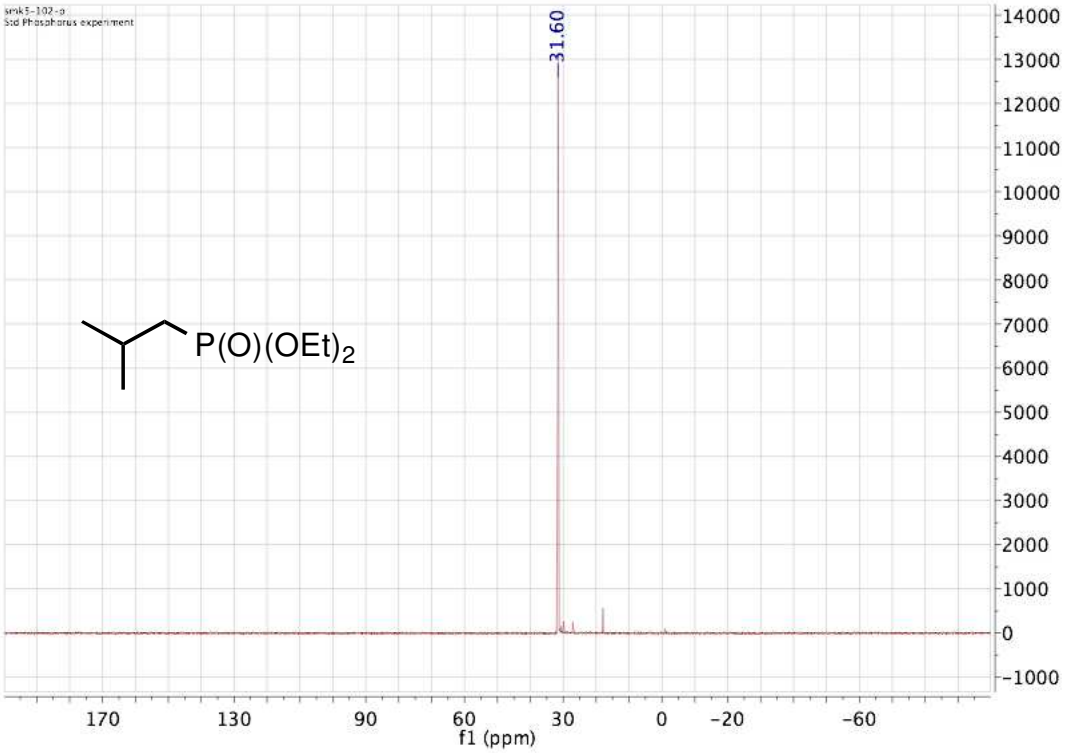
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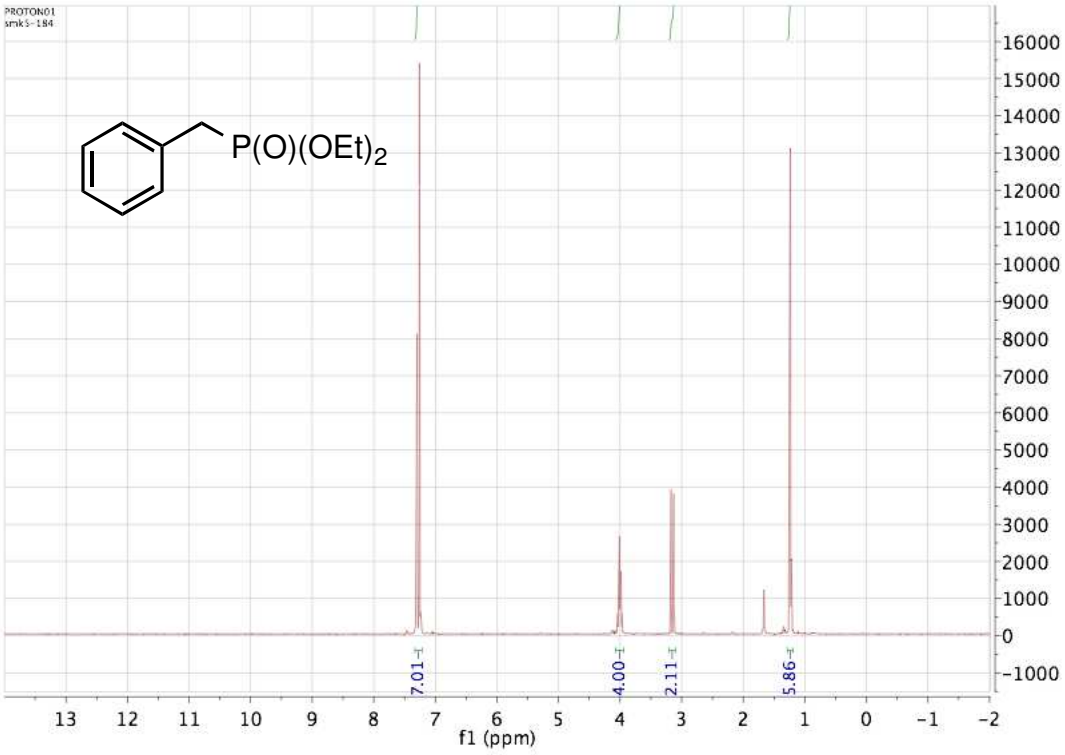
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8
7
6
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4
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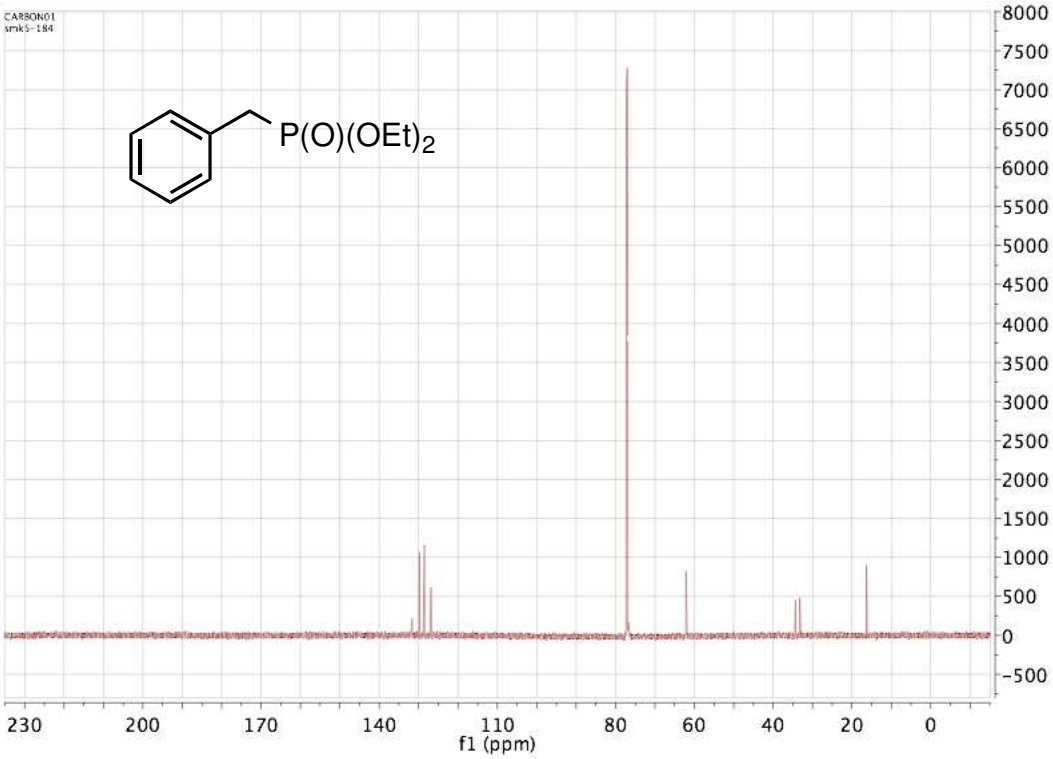
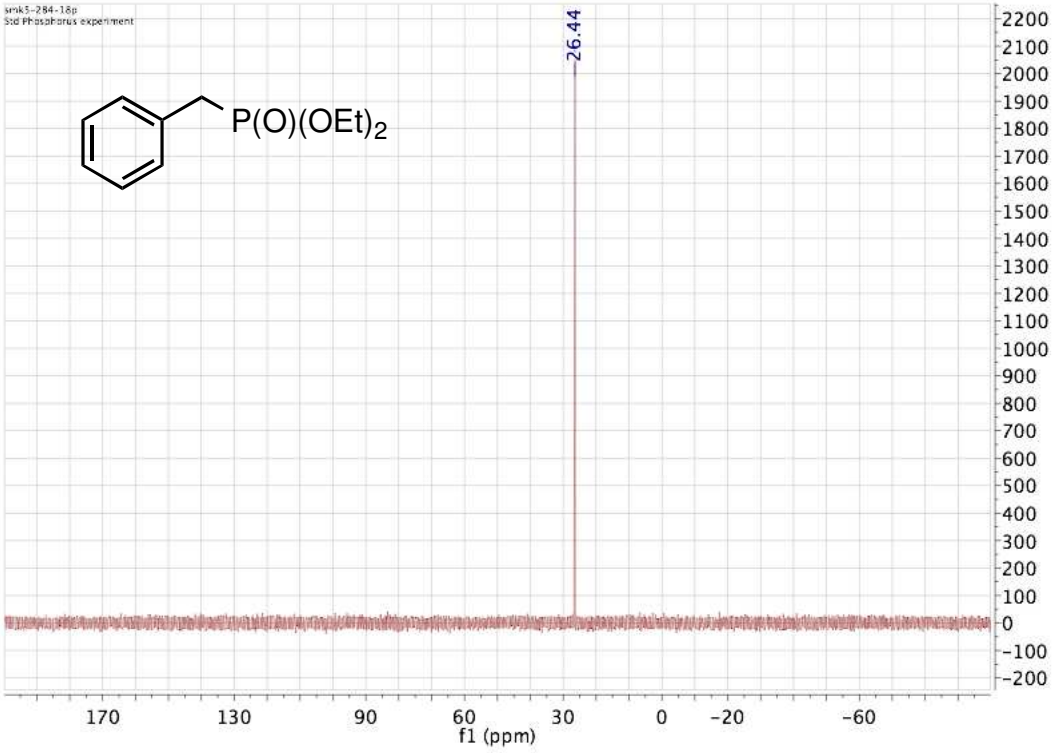
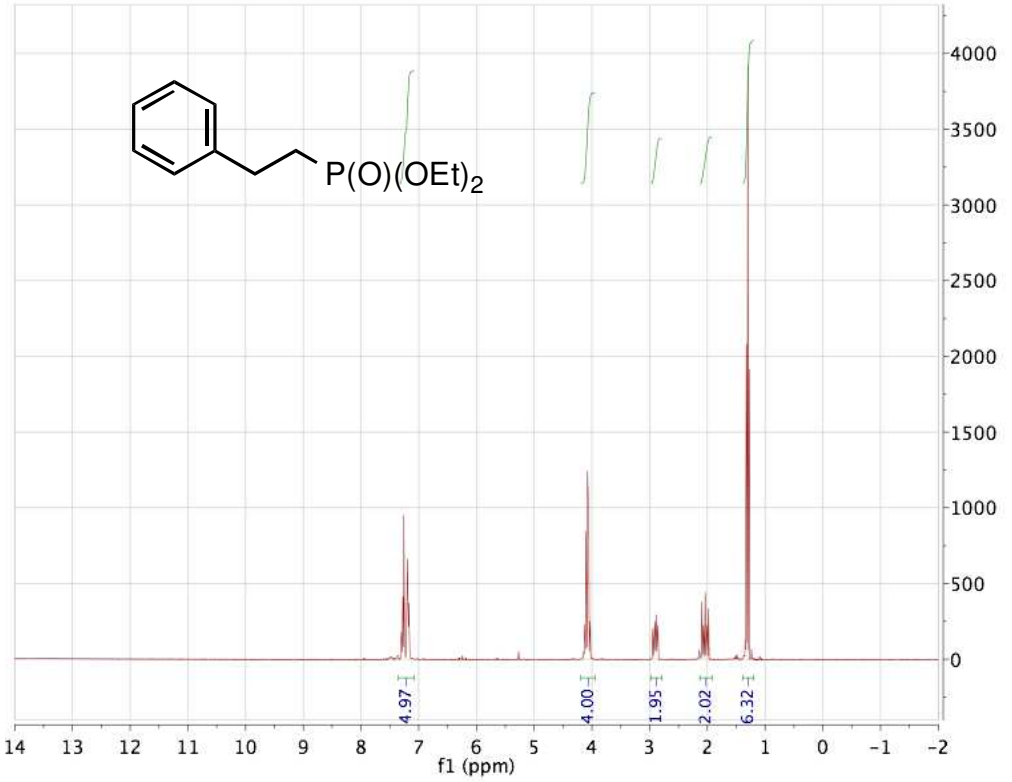
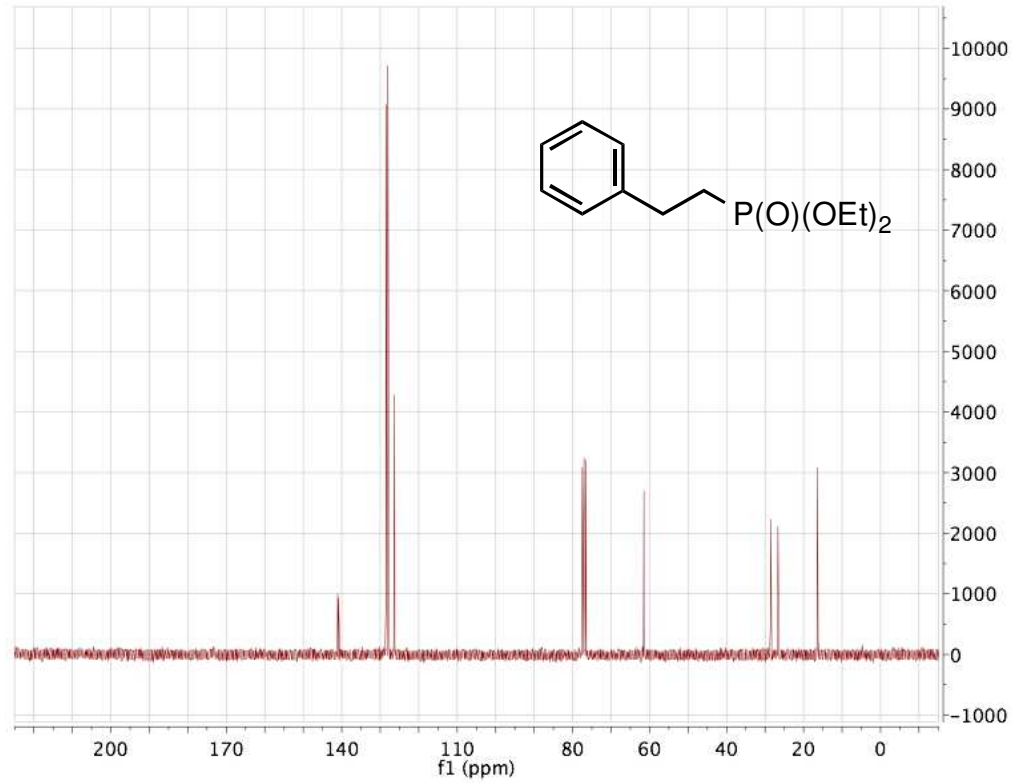
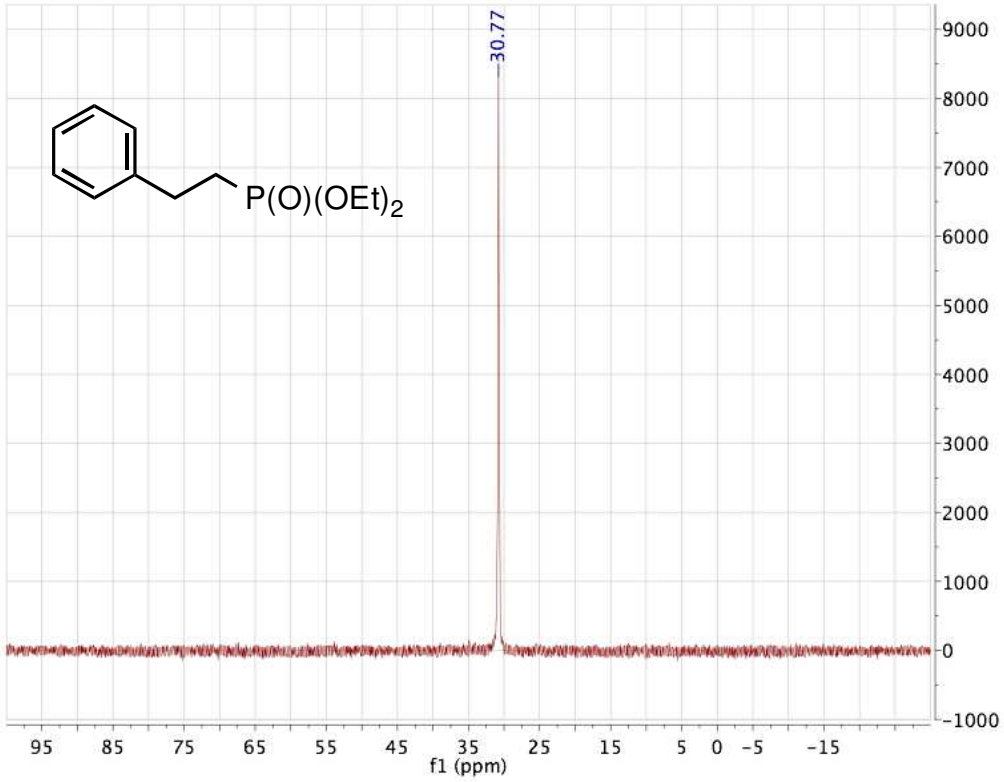
-2
f1 (ppm)

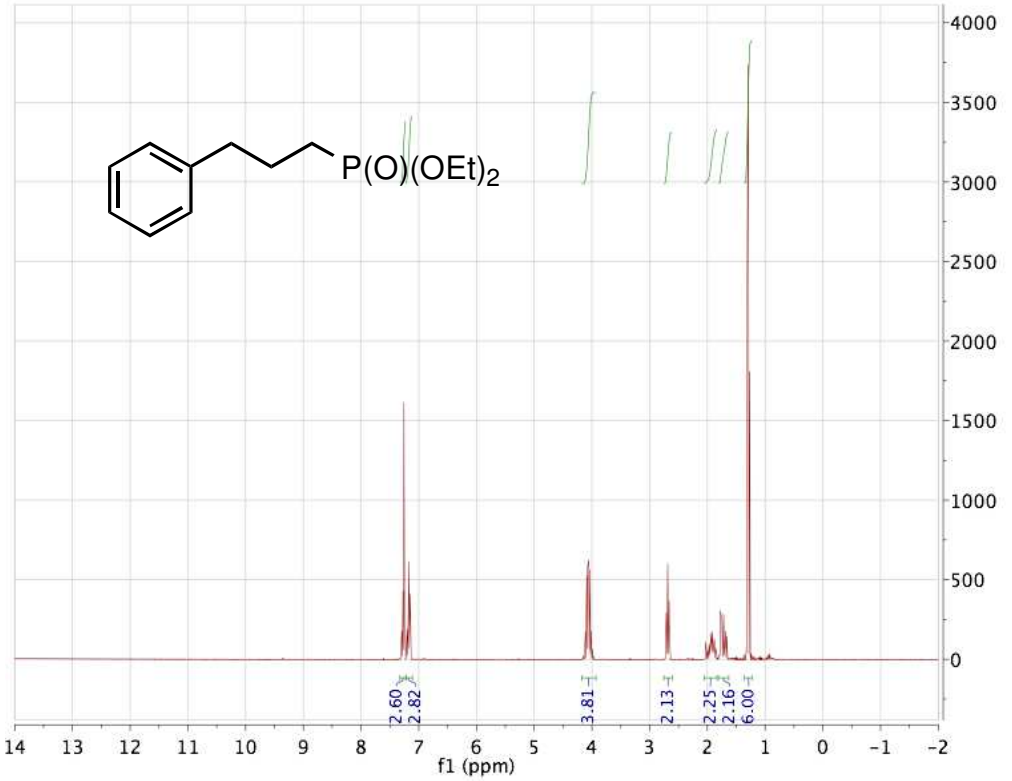

CARBON01
smk5-184
P(O)(OEt)2
8000
7500
7000
6500
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
-500
230
200
170
140
110
80
60
40
20
0
f1 (ppm)

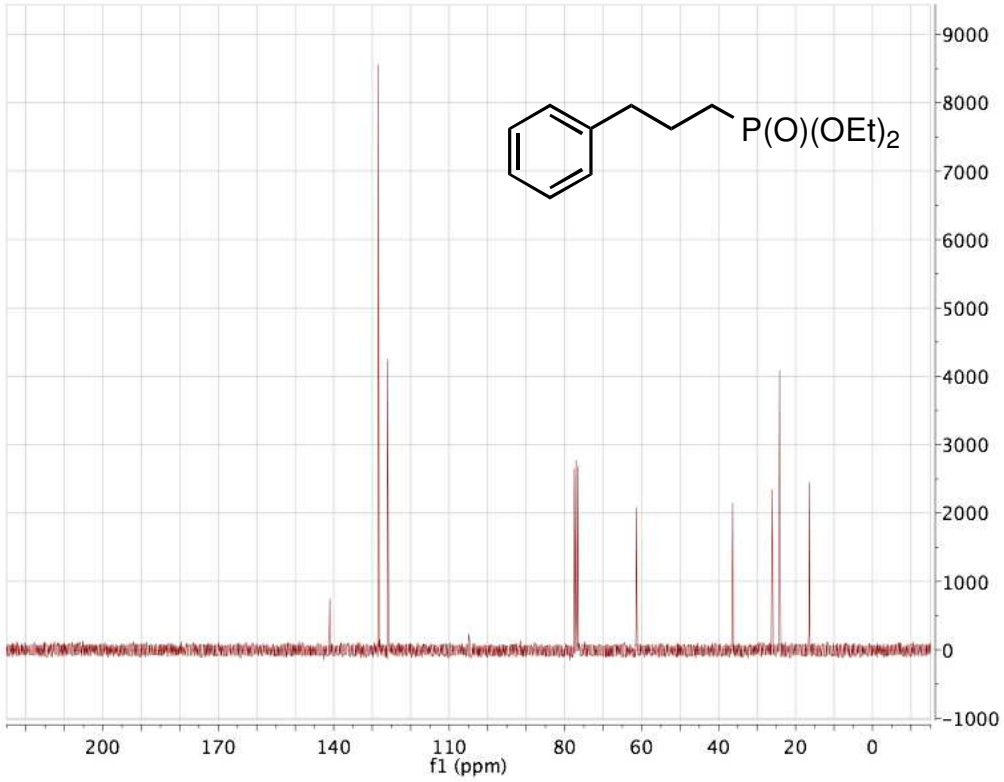

smk5-284-18p
Std Phosphorus experiment
26.44
P(O)(OEt)2
2200
2100
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
-100
-200
170
130
90
60
30
0
-20
-60
f1 (ppm)

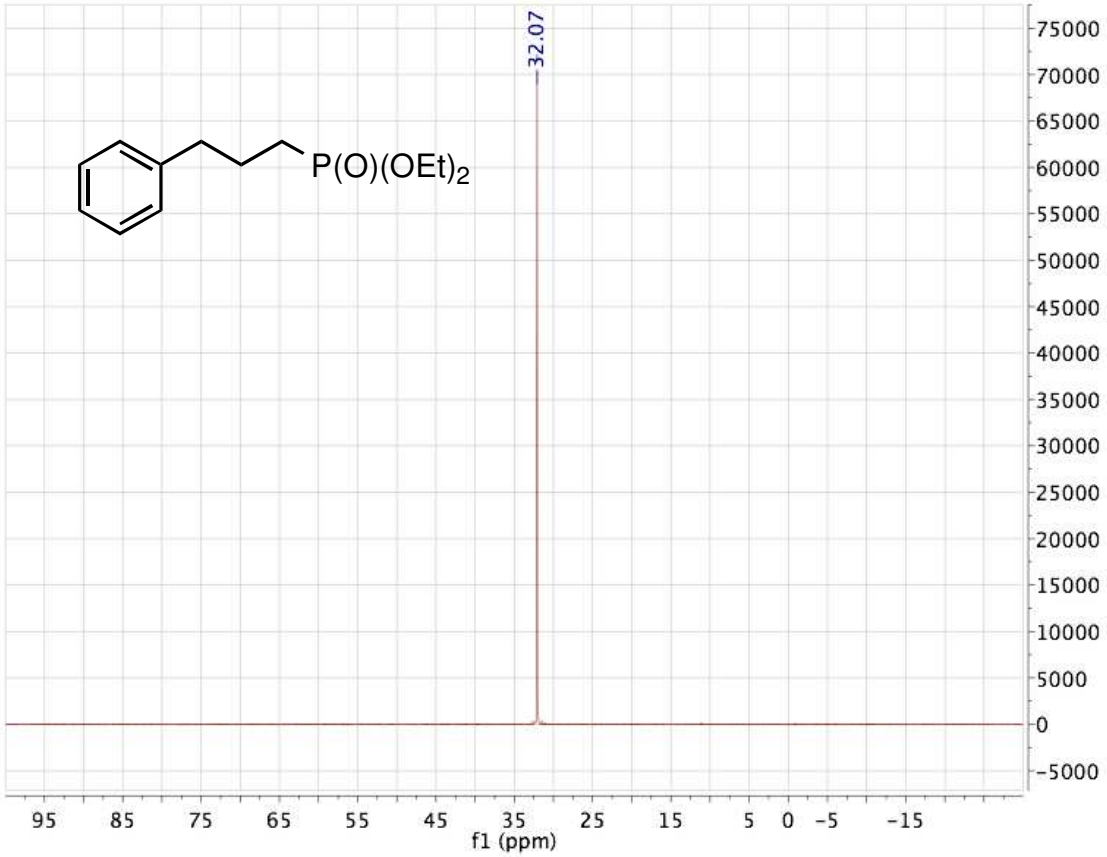

P(O)(OEt)2
4.97
4.00
1.95
2.02
6.32
f1 (ppm)

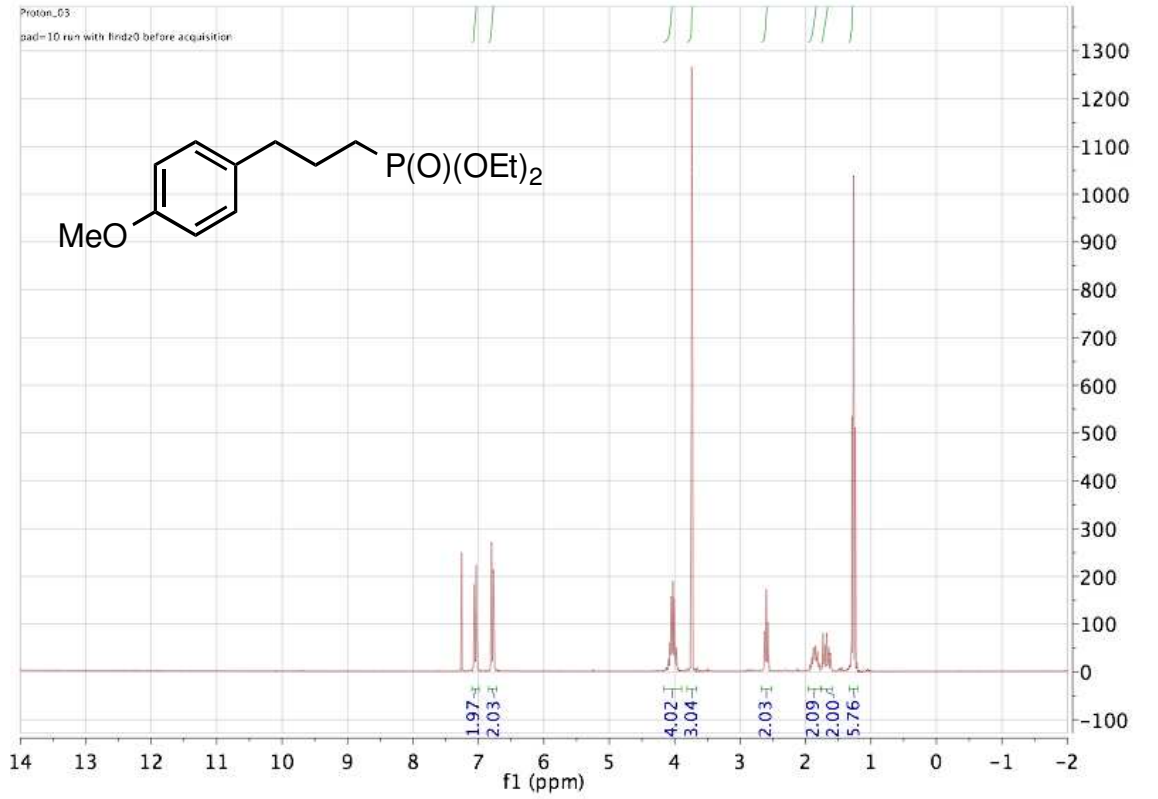

P(O)(OEt)2
f1 (ppm)

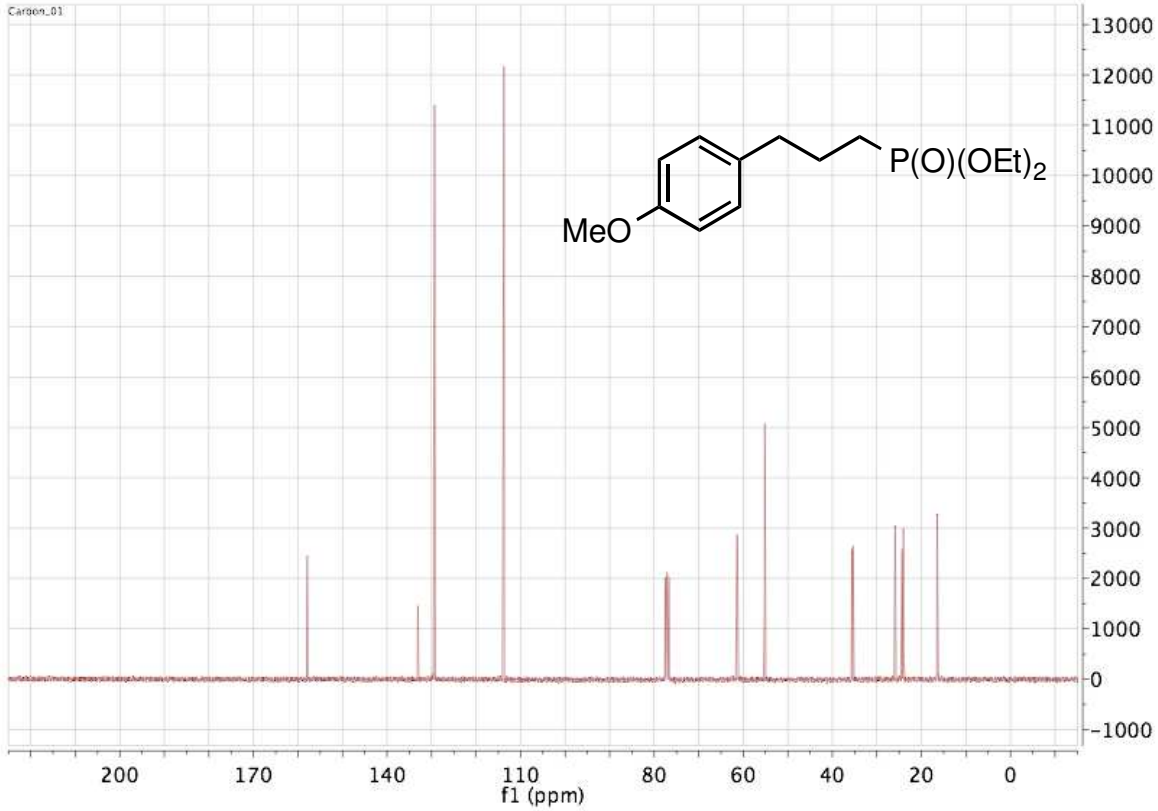

30.77
P(O)(OEt)2
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
95 85 75 65 55 45 35 25 15 5 0 -5 -15
f1 (ppm)

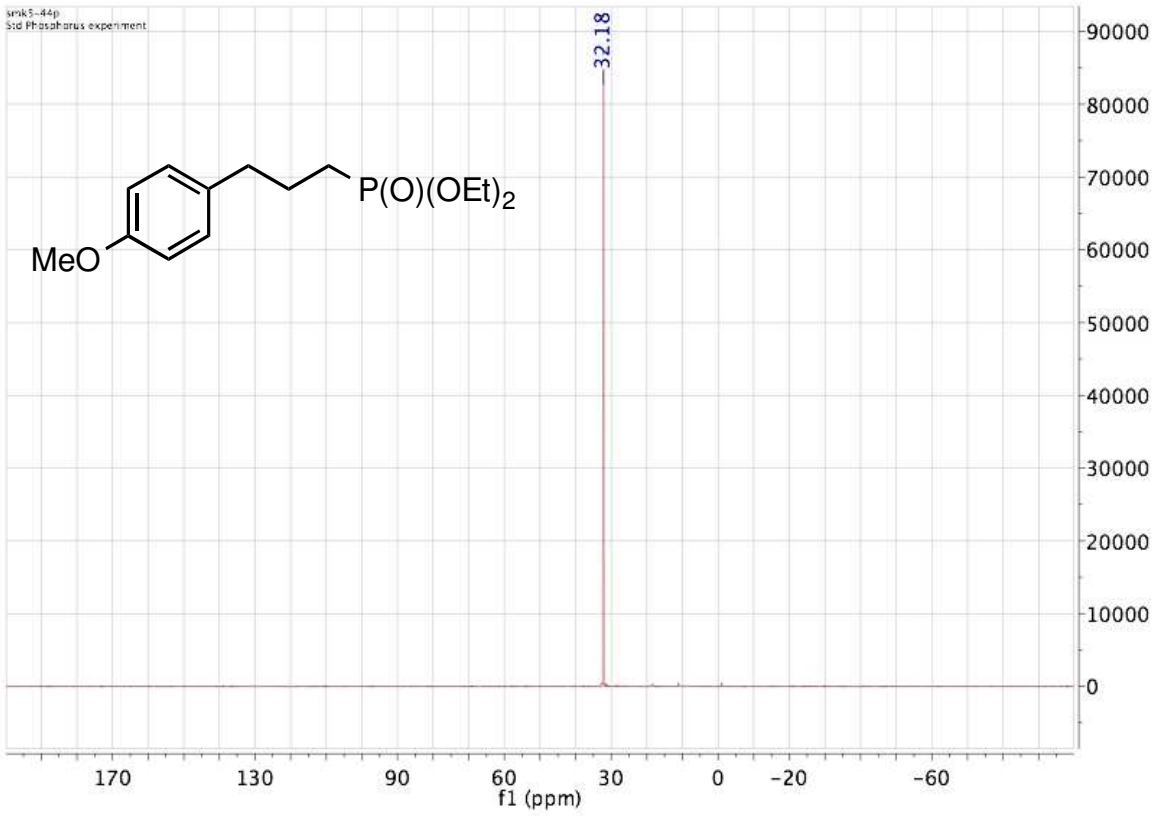

P(O)(OEt)2
4000
3500
3000
2500
2000
1500
1000
500
0
2.60
2.82
3.81
2.13
2.25
2.16
6.00
14 13 12 11 10 9 8 7 6 5 4 3 2 1 0 -1 -2
f1 (ppm)

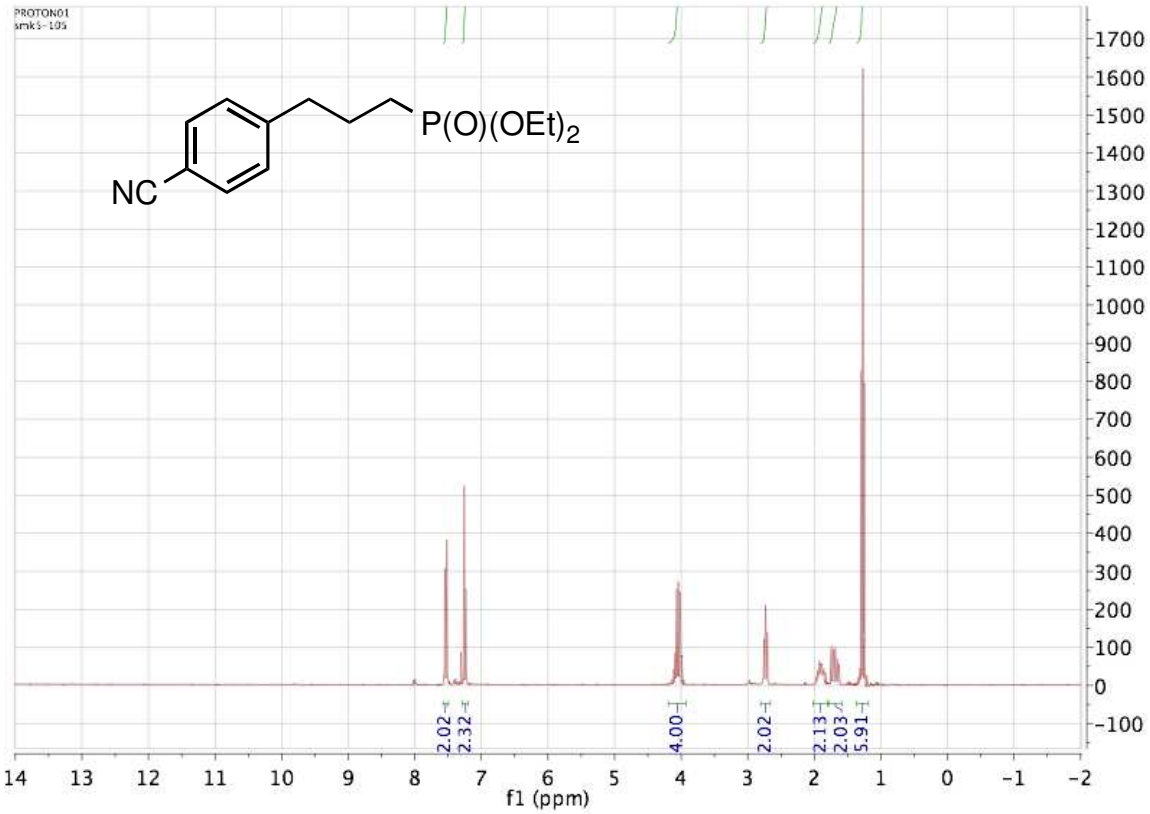

P(O)(OEt)2
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
200
170
140
110
80
60
40
20
0
f1 (ppm)

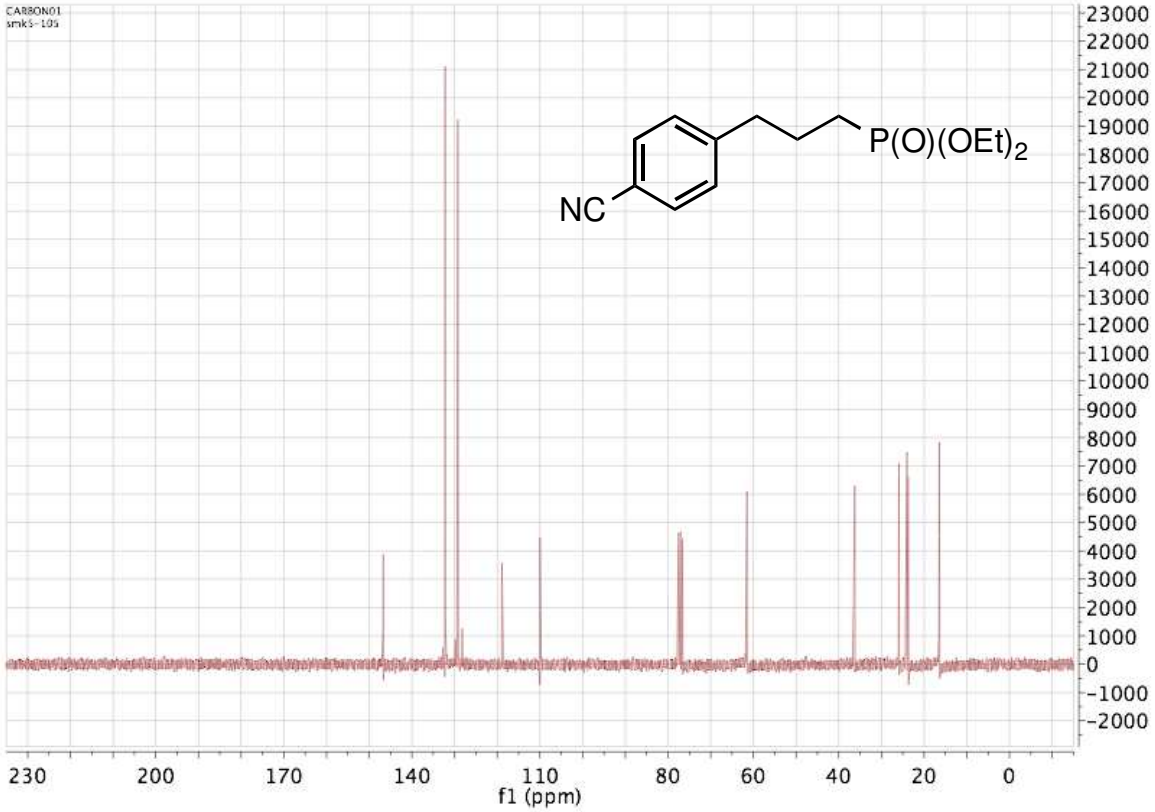

32.07
P(O)(OEt)2
75000
70000
65000
60000
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
-5000
95
85
75
65
55
45
35
25
15
5
0
-5
-15
f1 (ppm)

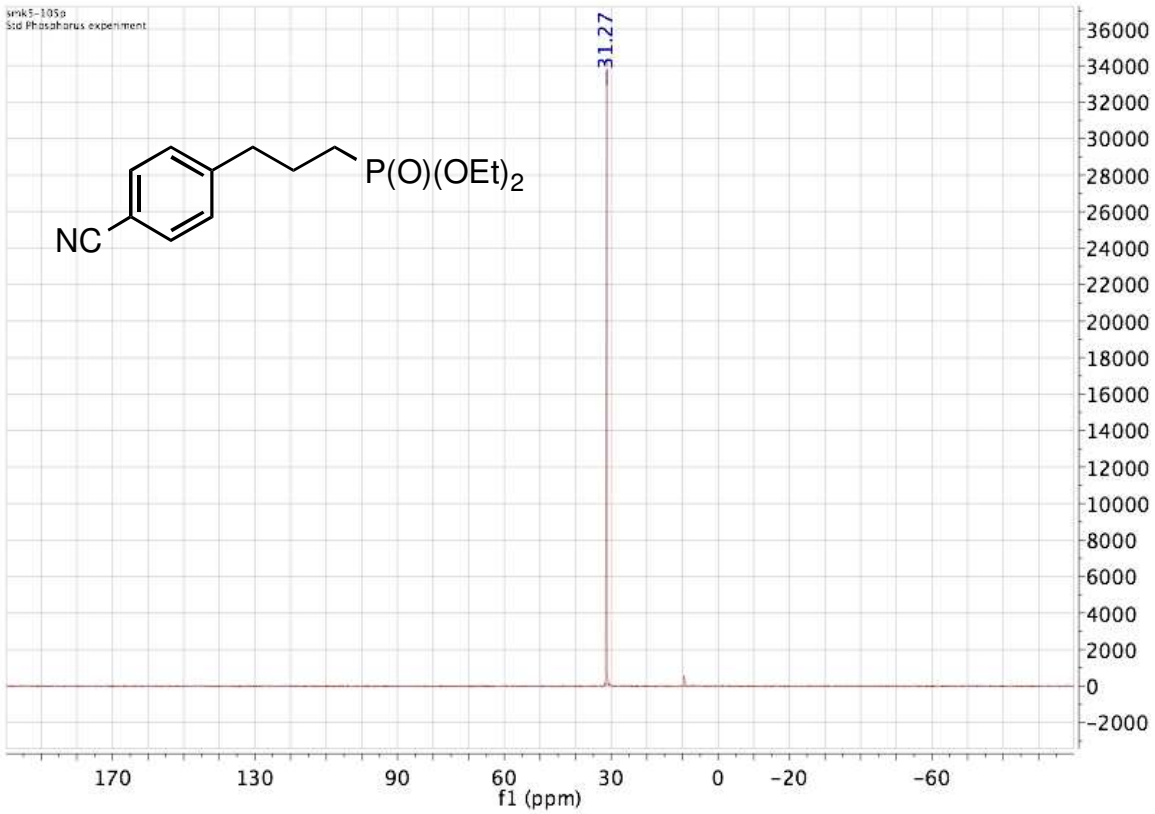

Proton_03
pad=10 run with findz0 before acquisition
P(O)(OEt)2
MeO
1.97
2.03
4.02
3.04
2.03
2.09
2.00
5.76
f1 (ppm)


Carbon_01
P(O)(OEt)2
MeO
f1 (ppm)


smk5-44p
Std Phosphorus experiment
32.18
P(O)(OEt)2
MeO
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
170
130
90
60
30
0
-20
-60
f1 (ppm)


PROTON01
smk5-109
P(O)(OEt)2
NC
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
-100
2.02
2.32
4.00
2.02
2.13
2.03
5.91
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
f1 (ppm)


CARBON01
smk5-105
NC
P(O)(OEt)2
f1 (ppm)


smk5-105a
Std Phosphorus experiment
31.27
NC
P(O)(OEt)2
f1 (ppm)

**References**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[vi] Characterization data matched those of a sample of the compound purchased from Aldrich

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